"CYBERSPACE ECOLOGISM 4.0": BETWEEN SOFTWARE SOFTENERS OF AND HARDWARE HARDSHIPS ON THE NATURAL ENVIRONMENT

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Abstract

Planet Earth, with its plethora of natural (im)balances, has a venerable age of 4.54 billion years; the (industrial) imprint placed by the human species on it, considered to be not negligible, counts of just little over two centuries; while the digital/IT&C/virtual existence of man, in what we call cyberspace, is reduced to just a few decades. An amorphous world, hastily assimilated to the Internet, the cyberspace is the sum or, better said, the synergy created by links between computers (and other compatible devices), servers, routers and various items of global IT and telecommunications infrastructures. A sort of fiefdom for tech computing power, but also a field of geo-political-economic power calculus, the cyberspace raises another dilemma: is it the salutary alternative to the bodice of a physical environment subject to depletion/plunder and degradation/pollution of its scarce resources? This article aims to capture, in an original way, how the translation of a great part of the world and social life into cyberspace, especially in the wake of the Fourth Industrial Revolution, relieves the natural environment/climate of Anthropocene pressures (e.g., via optimizations of production processes, favoured by artificial intelligence etc.), or, on the contrary, a less noticeable aspect, how it worsens certain components of it (e.g., via the amplified need for energy or for rare minerals, critical to new technologies etc.). Moreover, the above-mentioned ecological alleviations (labelled as of software nature) and (hardware) aggravations brought by digitalization are duly emphasized and evaluated in the light of the (un)intended consequences occurring at the highly sensitive intersection between markets (private practices) and states (public policies), pointing to the case of the European Union.

Keywords: cyberspace, natural environment, technology, ecology, markets, states, economic calculation, public policies.

JEL Classification: K32, N54, N74, O13, O14, P00, Q55, Q56

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Introduction

The history of mankind is defined by *technological revolutions* through which man has found new means to tame nature, to combine and process its elements so as to better satisfy his needs and wants. With each jump, mankind has shaped not only its own socio-cultural and economic structure, but nature itself. This series of ever more alert transformations is visible since the dawn of agriculture – which facilitated the transition from a nomad lifestyle to a sedentary one, thereby leading to the establishment of the first human settlements – to the industrial revolutions in the 18^{th} and 19^{th} centuries which have massively changed the face of not just the economy, but of society, in general, then to the digital revolution at the twilight of the 20^{th} century, when information emerged as an economic commodity and factor of production, bringing us to the ongoing Industrial Revolution 4.0, where we witness an acceleration of automation and the integration of communication, data collection and data mining technologies. Economic activities, regardless of their nature, require a supply of resources based on a triarchic structure: the *energy* needed to maintain operations, the *raw material* that will be processed to generate added value and crucial *information* for making optimal decisions. In this (eco)system that has become planetary/global, we see an increase in attention granted to the impact of *technologies* on the *natural environment*, with a focus on the (mostly negative) medium-and-long term consequences. Of course, there are also (scientific) opinions that encourage greater moderation in deflecting onto mankind *all* of nature's hazards (Schneider, 2020; Topan, 2021): if science ceases to be a sceptical-competitive process in which the accumulated conclusions could be rationally and responsibly contested, then science risks being of no use at all.

This article particularly questions the relationship between digitalisation and ecology, by highlighting possible connections between *the virtual cyberspace* and *the physical natural environment*; is the former an "alternative" to the latter?; does it mitigate the shortcomings/threats that nature has been facing due to the "excessively physical" existence of man?; or, rather, is this "virtual-ness" merely an illusion since any kind of soft(ware) has its hard(ware) requirements, intensive in physical raw materials and energy? Cyberspace has become a term that broadly describes the many interconnected cyber-technologies (Huidobro, 2021; Kerttunen, 2018). We have come to understand cyberspace as something that somehow exists all by itself: a collection of the aforementioned technologies. When people think of the cyberspace, they often associate it with concepts such as the internet, digitalisation, technology etc. Nevertheless, these cyber-technologies and this cyberspace have no existence in and of themselves: they are, in turn, part of a broader environment that hosts them, which Akhgar and Brewster (2016) coin *cyber-ecology*. The internet, the electronic devices and other technologies within cyber-ecology (or "cybernetic ecosystem") are mere cybernetic organisms that would have no meaning or identity of their own beyond their interaction with their environment. The problem therefore moves towards the relations between these two environments/ecosystems: can the cyberspace aid natural processes currently in a human-induced disequilibrium to regain their balance via complementarities (e.g., superior computing power to optimise productive operations) or substitutions (e.g., by relocating consumption habits to the virtual dimension of life) – which we henceforth call the "soft side"? Or, on the contrary, will it simply add to the pressure on the environment – its "hard side" (e.g., by a growing need for critical supplies and energy)?

In this dilemmatic landscape, the most synthetic presentation of the 21st century's *zeitgeist* can be expressed thusly: environmental problems are the main challenge faced by the human race, while digital solutions are the main opportunity that our species can avail itself of for various problems, including those relating to our environment. Against the backdrop of public pressures caused by increased awareness of the current ecological challenges and the opportunity of digitalisation, national and supranational decision-makers have set out to undertake the necessary measures to resolve the problems threatening our natural environment by making use of digital solutions to as great an extent as possible. In other words, public authorities are counting on "technological" efficiency to tackle an otherwise "juridical" issue – that pertaining to the liberties/responsibilities of the exploitation of quantitatively and qualitatively critical resources. The present paper is structured according to the following line of reasoning: once a review of the existing literature is performed, we proceed with the main reflection on the relationship between *law* and *legislation* and how it favours synergies or conflicts between the digital and ecological transformations of contemporary society (e.g., at the level of the European Union); the next two sections take stock of the virtuous and vicious links between (digital) cyberspace and the (physical) natural environment, pinpointing a series of unintentional consequences born of a legal framework that, by enforcing the digitalisation and greening of the economy/society, it causes disequilibria and instability in the "eco/system"; in order to give our analysis a particular scope, we further discuss the "case" of the auto industry in Romania. The original component of our present paper is derived from drawing attention to the vital need for *realism* so as to maintain even (or, perhaps, especially) a viable kind of *idealism*.

1. Literature review

Cyberspace – whether it duplicates the real world or usefully complements it – electronically perpetuates human action with its social, cooperative, as well as statal, coercive expressions. Societal events have their own metabolism in the cyberspace, augmented by the nature of the information society, while at the same time they create opportunities and threats to freedom and democracy. Beyond all the benefits of cybernetizing human existence – at the level of mega-processes, but also in a mundane sense –, cyberspace hides dangers not only from the perspective of totalitarian regimes previewed in the dystopias of Orwell, Huxley or Zamiatin, where computers, artificial intelligence, robots etc. are used to monitor almost all the facts in the lives of their citizens, but also in covert control, in the name of democracy, aimed at filtering beliefs and actions and re-instilling a "majority" fed systematically by pseudo-information packaged in bits distributable at the speed of light (Jora, 2018). Apparently wide, the cyberspace can also "squeeze" us (for instance, how will *we* be in the *Metaverse*?).

Cybernetics is the science of control and communication *intra* living or automatic systems, but it is also the science of communication *inter* "animal" and "machine" (Tabacchi, Termini, 2017), hence between *nature* (given) and *nurtured* (artificial). Cyberspace is also the "jurisdiction" that "governs" the logic of the connection between cybertechnologies (created by human intelligence) and nature/environment. In this new type of posthumanism – viz., where humanism assumes that man is autonomous, conscious, intentional and exceptional by the power to change the course of events, posthumanism sees action as determined by dynamic forces in which man participates, but does not intend or control them completely, as in cyberspace – new questions arise. One of them: can cyberspace help

man, with his environment, by saving him from the plunder and degradation of natural resources? An answer to this question can be formulated regarding both the paths of the relationship of *homo cyberneticus* (the *new* technological man, yet not teleologically altered) with the old natural environment (of the continuous Anthropocene).

"The reverse look"

To begin with, let's look at the ecological realm from the point of view of the digital: is a vast consumption of natural resources necessary to ensure the existence of cyberspace? As McCarthy and Ondaatje (2002) note, scarce (natural) resources are allocated to meeting informational needs – obviously, not everything can be reduced to *software*; there is also a *hardware* component that necessitates raw materials and energy. In this case, a reinterpretation of the first question reads as: is the cyberspace capable enough to contribute more to relieving the environment from anthropogenic pressure than it consumes for ensuring its own existence? Or, from another perspective, is the cyberspace a viable alternative (to the protective measures that the human should take towards the environment) by the mere fact that it shifts the human's attention from his eminently physical nature, providing him with a new route to access prosperity?

Sceptics answer the two questions using two broad types of arguments: that of the *ecological footprint* and that of *legal asymmetry*.

The ecological footprint. New technologies and hyperconnectivity associated with cyberspace do not come without challenges (European Commission, 2021). Some jobs will be lost through automation – in the EU alone, in 2018, about 14% of adult workers faced very high risks for this reason, being estimated that, in the future, 50% of currently globally existing jobs could be automated, differently between countries and sectors. But beyond social disruptions, the digital transition poses environmental problems in several ways: (i). it can increase electronic waste (or e-waste) (European Parliament, 2021); (ii). it will amplify the energy demand, for example a huge one when it comes to supporting the processes that are based on blockchain technologies, especially on the cryptocurrency component (Cho, 2021); (iii). the use of scarce resources ("rare earths"), amid uneven global distribution, fierce geopolitical competition and low recycling rates, will favour the use of relatively more environmentally invasive/toxic technologies (DW, 2021).

Legal asymmetry. Cyberspace is considered an unconvincing alternative to physical space (more strongly related to the natural environment) because it is not well enough regulated and harmonized globally: there is not enough international consensus regarding the rules and principles that govern the cyberspace (Han, 2018), which increases the unpredictability/uncertainty of those who would like to migrate with components of their businesses towards it. Lessig (2006) considers that this failure to regulate cyberspace is partially offset by the fact that it is to some extent regulated from within, that there are communitarian codes of conduct, on the basis of which netizens act when browsing online. Biegler (2003) even considers that cyberspace is impossible to regulate, simply because it does not respect the contours of national borders and the jurisdictions defined by them (Ruijgrok, 2021), putting entrepreneurs between the Scylla (of endless opportunities) and the Charybdis (of unlimited threats).

“The look forward”

Let’s now see how cyberspace opens up new opportunities for productivity management, metabolizing useful data for managerial decisions (Jeske et al., 2020), productivity being, in principle, an ally of ecology. *Business intelligence (BI)* tools provide visual representations following the analysis of historical data, as well as those data accessed in real time, and the continuous development of user-friendly interfaces makes BI tools more and more accessible. Decision makers’ access to both historical and real-time data means unprecedented volumes of data that can be analysed and used to increase productivity and, as El-Thalji et al. (2020) show, this also leads to strategic implications, as corporate strategies will be reoriented to new productivity opportunities. A general belief that data would represent the “new oil” of the industry is beginning to take shape: the metaphor is based on the idea that both oil and data can be of major importance for industrial production, but only after prior processing (Taffel, 2021).

The artificial replaces the natural, protecting it. Steps have already been taken towards greater respect for the environment with the help of computing technologies, such as 3D printing, through which new artificial resources are created in order to be used as valid substitutes for natural resources, which can thus be much better preserved (Kutukova, 2019). Thus, digital technologies can help stop the vulgarization of natural resources and, through their better use, to inclusively support biodiversity.

The accessibilization of ecologically critical information. According to Lévêque (2003), the main contribution of cybernetics to a cleaner ecosystem is that it provides the informational and communicational means for actors in the economy to exchange knowledge among them so that they can make concentrated decisions that better protect the natural resources (if, of course, they wish this). Proper access to relevant information is essential for economists/administrators/entrepreneurs to substantiate/make optimal decisions.

For this to happen, a clear understanding of the eco-system and of the polluting factors is needed; cybernetics can shed more light into complex matters that often confuse decision-makers. To Kalymbek et al. (2021), this is nothing else than a step towards civilization. Only when the human being will stop his chaotical decisions regarding the use of resources and will improve them by the adoption of digital innovations, the environment will become a natural, innate ally again.

But here as well, in educating and norming behaviours, one must understand the consequences of opposing *artificial laws to the laws of nature* (including *of human nature*). In the next section, a logical analysis will be performed on two levels: (i). the “legal problem” – *law* versus *legislation* and (ii.) the “institutional problem of economic systems” – the consequences of *state intervention* in *market laws*. In its extension, concrete instances can be pursued in which the digital and ecological (legislated) targets are synchronized or undermined.

2. “Law” and “legislation”, “digitalization” and “ecology”: some parallels and intersections, compromises and synergies

The following analysis avoids weighting social costs against benefits – due to the epistemological/methodological limitations of such an endeavour (Iacob, 2016) –; what we

propose is more modest (and, yet, much more scientifically robust): we shall analyse the consequences that stem from employing certain means, i.e., what results follow from abiding the law (and the laws of the market) versus the consequences of enacting legislation that seeks to change the way in which the market would allocate resources, towards a given end, i.e., achieving eco-efficiency through an effective allocation of resources with the help of digitalization. This approach will prove useful for understanding that although some legal norms are the product of democratic decision-making, they lead to unintended consequences – e.g., applying different/divergent types of rules for tackling a problem can produce unanticipated disequilibria with adverse consequences.

The distinction between *law* and *legislation* (Leoni, 1991; Kinsella, 1995; van Dun, 2009; Hayek, 2012) can be achieved, with the least amount of ambiguity, by beginning with the concepts of *liberty* and (property) *rights*. By *law* – here to be understood as "natural" and "rational law", and whose contradiction would go against human nature and would imply logical contradictions (Rothbard, 2003; Hoppe, 2010) – we mean the respect for the absolute sovereignty of each individual over his own person (self-ownership) and those material goods, viz., scarce resources which are obtained through the use of economic, voluntary means (appropriation, production, exchange, gift or inheritance). As long as the legal norms do not come into conflict with the physical integrity of private property or the voluntary given consent of all the parties involved, we can affirm that all social relations are in accord with the *law*, in other words, they are *legitimate*.

By *legislation* we understand the sovereignty of the legislator. Its will is expressed through enactments (e.g., acts of parliament, regulations that emanate from the executive branch) which can be in accord with the *law*, namely, by recognizing justly obtained private property rights, or contrary to it. For example, anti-social acts like murder or theft represent, without any shadow of a doubt, infringements of both *law* and *legislation*. In this case, we can say that the *legislation* entirely reflects the *law*. Conversely, the partial sanctioning of pollution and the permission granted for the continuation of such anti-social behaviour as long as the polluter pays a tax or acquires a given number of green certificates ("pollution rights") represents an act that goes against the *law*, but which is permitted by the statutory *legislation* (Rothbard, 1998).

When the *law* and the acts of *legislation* coincide, social relations tend to be harmonious, while any deviations from socially compatible behaviour are only accidental and supressed by the law through the means of legislation. However, when the law is at odds with the enacted legislation, social relations tend to be systematically short-circuited, conflict substitutes harmony. If the scope of any law is to make peaceful social cooperation possible in the context characterized by scarcity, legislation can be at odds with this requisite, leading to more conflict that it addresses. This discussion also touches upon the difference between *capitalism* – the order that stems from private property – and *interventionism* – the incomplete order in which the state acts to deviate the allocation of resources through regulation, taxes, and inflation from the way their lawful owners would have chosen.

The discussion related to solving the *ecological* problem by the use of the *digital* potential can be organized starting from the *law-legislation*, respectively *capitalism-interventionism* matrix (Figure no. 1). There are four planes with overlapping surfaces, as well as solitary surfaces.

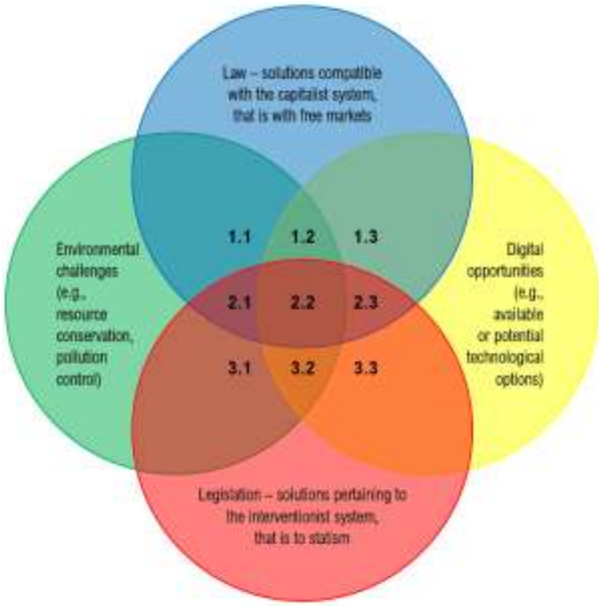

Figure no. 1. Environmental challenges and digital opportunities at the intersection with the law and legislation

Deciphering diagram (I) – "Law = legislation" in matters concerning digitalization and the environment

Pertaining to the two discs that depict the subject matter of the *law / capitalism, the market economy*, respectively the area of *legislation / interventionism, statism,* we can say that where these two surfaces are superimposed (*2.1*, *2.2*, *2.3*) only commonly addressed solutions are available, i.e., the legitimate resolutions are entirely reflected by the legislation. This means that the law and legislation are in harmony, which leads to social cooperation and the rapid resolve of potential conflicts.

Discussion. Here we could place a legal provision which states that the owner of an energy resource, for instance petroleum, can freely dispose of it, as it is his purview if and at what price he will sell it. What makes petroleum an economic resource is its scarcity when related to the needs that can be satisfied by its use (Reisman, 2003). This fact is recognized as such by the individual that embarked upon the geological exploration for the oil deposit and who committed the necessary complementary resources for this endeavour. This individual has employed only economic means (private property and contractual agreements) to identify (what was until the moment of its discovery) a potential resource which had not been claimed and significantly transformed before him by any other person. Consequently, we can assert that there is no one else that has a stronger, better justified claim on the oil deposit under discussion. Also, considering that the given resource did not belong beforehand to anyone else – until that moment it was not even clear if its existence was known –, it cannot be maintained that the act of appropriation has affected the physical integrity of a third party's property (Herbener, 2009). If the full control over this resource is recognized as such by the legislation in force, the *de jure* and *de facto* owner having all his

consequent rights acknowledged, including that of disposing of the oil as he deems fit, we can say that the legislation reflects the law, an ideal situation from a social point of view.

Starting from the aforementioned example, we can now add to our discussion the other two spheres: the challenge posed by the environmental related issues, respectively the technological/digital opportunity.

Discussion. The *2.2* area represents the surface where all four spheres are superimposed. The law and legislation are in harmony, similarly with the previous example, and the same thing applies to the challenge represented by the environment and the digital opportunities. In matters regarding our example, this means that the owner of the given resource chooses to invest in available digital solution to increase the economic efficiency of his operation. By employing monetary calculation, the owner finds it's lucrative to invest in the technological solution which he appreciates to be the optimal way forward considering the future price of the oil that is going to be extracted and offered for sale. The life span of the investment, the timing of the drilling operation and the sale of the output are harmonized in light of the prevailing interest rate (the intertemporal price), while at the same time accounting for the future evolution of the sale price and the costs implied by the production process. In this way, the available stock of fossil fuel is permanently economized, thus reflecting to the best possible extent the present and future preferences of the consumer. Thus, the rationalization of the use of natural resources becomes manifest through monetary calculation. An individual who is willing to undergo a longer time interval before tapping the oil resource (someone who is more optimist when it comes to the future price of the respective resource) can opt to buy the entire deposit from its current owner. Therefore, in area *2.2,* the decisions pertaining to resource extraction, investing in more efficient technology, and storing up resources implicitly reflect the preferences of all members of society, the interaction between all individuals thus tend to be harmonious (the precondition for "social efficiency").

In what concerns the areas *2.1* and *2.3*, we are still at the intersection between law and legislation, but only one of the other spheres – the environmental challenge and the opportunities represented by digitalization – coincides with the two planes that correspond to the rules of the game.

Discussion. Basically, area *2.1* represents the scenario in which the environmental problem can be addressed in a way which is both lawfully and legally compliant but in which technological solutions cannot be economically employed: there is either no available technological solution for that specific problem, or the costs of the technological solution make it economically unviable, as the prospective profit calculations reveal that it is not worth addressing the respective ecological challenge by directing capital toward it. For instance, maintaining the pristine state of certain ecosystems, until now undisturbed by human activity, implies, by definition, withholding the use of any intrusive technology – it goes without saying that this constraint becomes laxer as wireless technology and satellite imagery are perfected, however we must keep in mind that there are still clear limitations in what technology can achieve in this case. Regarding those activates where digitalization cannot be economically employed for protecting the environment, there are numerous examples that can be put forward. Capital continues to be scarce, i.e., it can be more profitably employed toward achieving other ends, to be allocated toward certain environmental objectives. For example, we could refer to the lack of economic viability of electric cars. This segment proliferated thanks to the substantial direct and undirect

(e.g., the charging infrastructure) subsidization that it received. Without this state-sponsored allotment, this technology would not be able to compete, at least for the time being, with autos powered by internal combustion engines. Our society must accumulate more capital so that investing in such technologies may become viable – a question of economic growth and waiting.

Deciphering diagram (II) – "Law ≠ legislation" in matters concerning digitalization and the environment

We will continue our analysis by referring to those interactions that can be subsumed under the aegis of areas *1.1*, *1.2*, and *1.3*. We are in the scenario in which the *de jure* owners want to pursue a certain type of action which is not permitted by the statutory legislation, although it is a lawful action – namely, it does not damage in any way the physical integrity of a third party's property.

Discussion. Area *1.2* in our graph includes digitally and environmentally wise feasible/ profitable opportunities which are also regulated by the state. For instance, we can conceive of a situation that falls under "triangular interventionism" (Rothbard, 2009), in which a company wants to install sensors for monitoring air quality but the legislation expressly prescribes what equipment is to be used and what suppliers are licenced to offer the necessary services, thus forbidding any alternative solution – see the literature on rent-seeking (Tullock, 1967) and that on the costs of regulation (Stigler, 1974). Areas *1.1* and *1.3* encompass those scenarios in which the free market identifies environment or digital solutions, but the state has enacted regulations that prohibit their implementation or make them prohibitively expensive through the taxes it imposes. Some examples: for *1.1* – the 19th century legislative acts that exempted industrial pollution from tort law provisions fearing that the strict application of the common law would have retarded industrial development (Rothbard, 1998), or the expropriation for reasons of "public utility" of natural resources, otherwise more valuable ("on the market") left specifically unexploited (e.g., the Brazilian Amazonian forest), or the supplementary taxation of those individuals that want to keep their land uncultivated; for *1.3* – the idea of "the stifled entrepreneurial process" (Kirzner, 1995; Ikeda, 1997) comes as a consequence of regulation like that which seeks the elimination by 2030 of all petrol and diesel powered cars, thus forcing a transition process which comes with a number of impossible to gauge costs (e.g., freezing up all R&D expenses that could have produced even more efficient internal combustion engines thus replacing a potentially more eco-friendly solution with pollution-generating alternatives like toxic battery residue and electricity which is sourced from unregenerable sources)

In what concerns the areas *3.1*, *3.2*, and *3.3*, we are in a situation in which the stipulations of the legislation go against the grain of the requirements set forth by the law, ignoring even the economic costs involved by the decisions that seek to direct resources toward the objectives that are preferred by the legislator when it comes to the environment and digitalization. The three areas include those situations that fall under the incidence of interventionism, an expression of statism.

Discussion. Area *3.2* of our graph can accommodate the EU's strategic documents, like the *European Green Deal* (Comisia Europeană [European Commission], 2019) and *Shaping Europe's Digital Future* (Comisia Europeană [European Commission], 2020). Here we include all public policy measures that seek to bring about a *New Digital Green Deal*, namely, to mobilize the potential of the new technologies to address the environmental

risks. All these proposals ignore the logic of private property, attempting to accelerate the market's natural processes and to alter the structure of the economic sectors – an economy which is "greener" and "more digitally advanced" compared with the outcome that the unhampered market would have produced. As we are going to show in the following section of the present paper, all digital opportunities also involve costs. Area *3.2* includes such subjects as "the entrepreneurial state" (Mazzucato, 2018), a concept which can be integrated in the wider literature concerning the industrial policy and the state as promoter of economic development. More recent discussions related to the *Great Reset* have been undertaken in the same spirit. Whether the state is a good innovator or entrepreneur and what does its track record tell us about its performance in these areas since it arrogated to itself such objectives have generated much controversy among the economic profession (Lerner, 2009; Rothbard, 2015; McCloskey & Mingardi, 2020). In this regard, we will also refrain from engaging in this intellectual dispute, in order not to strive too far from the subject matter of our article. We will have to settle with pointing out that economics is far from reaching a consensus in matters concerning the (in)efficiency of the state *qua* investor – or, from an even higher vantage point, its (in)efficiency as active player and referee.

Next, there will be a discussion about concrete situations in which, including interventions in markets, by pursuing public policy objectives in the area of digitization and/or greening, the relationship between cyberspace and the environment becomes either harmonious or antagonistic (Figure no. 2).

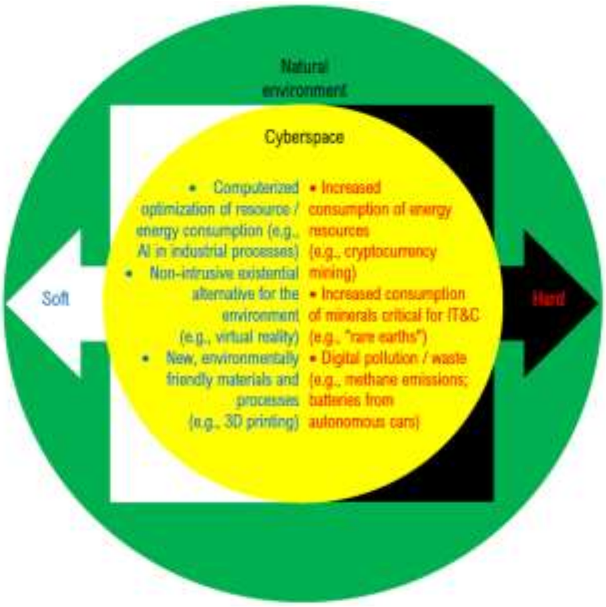

Figure no. 2. Software softeners of and hardware hardships on the natural environment by means of cyberspace

3. The "soft(ware)" side. The digital relieves the environment: the computerization of eco-friendly production processes

The first inference that this study advances is that according to which the impact of digitalization, of the cyberspace (as a sum of digital solutions), is favourable to greening, especially on the "soft" side of the relationship. Computational power, that reached unprecedented values during the Industrial Revolution 3.0, can be used to minimize consumption of material resources and energy, pollution and ecological imbalances in the new 4.0 paradigm, dominated by key-technologies such as Artificial Intelligence, Big Data, Quantum Computing. Because digitalization is a relatively new ingredient in the economy, it is not yet clear how much and what kind of effect it has on businesses – ecological, but, above all, economic. The main concern in this regard is that while digitalization helps highly polluting industries to improve their environmental performance by reducing the harmful effects of problematic production technologies, which have been replaced by "green" versions, this does not necessarily and immediately translate in a higher total productivity of the factors of production.

This idea is in line with the previous analysis "of principle": against the background of an inconclusive way of internalizing negative environmental externalities – error of legal design that does not clearly address pollution in the logic of property rights, but as failure of the free market (Cordato, 2004) –, there are obvious delays at the level of the economic agent, due to the profitability calculations that would not recommend investments in technology/digitization. Businesses are adapting relatively slowly due to high transition costs, related transformations of business models, as well as the many question marks still associated with the transition to a greener economy (von Wecus and Willeke, 2015). The call for public interventions to accelerate digitization and make the economy more environmentally friendly is the "expeditious" technical-political route, but economically and socially "expensive" when ignoring the fact that there are also national (Wasko et al., 2011) or sectorial (Krever, 2020) specificities: e.g., in the European Union, "one size fits all" is anti-convergent and anti-cohesive (Jora et al., 2021).

Under certain conditions, publicly regulated requirements may be considered compatible with the economic situation. In the spirit of the German *Industrie 4.0* policy, Haag et al. (2018) propose a framework (appreciated to be viable) for digitizing the industry in six stages: i. companies collect raw data on the natural resources used (e.g., energy consumption extracted from suppliers' invoices); ii. more advanced software extracts relevant information through data mining; iii. further, machine learning tools process data; iv. now come the algorithms and automation tools, which analyse the data obtained to predict production results, offering a better overview; v. the computer suggests decisions to improve resource allocation and increase efficiency; vi. fully automated systems are put into operation – business intelligence analysis tools are correlated with sensors on the production equipment, and various hardware and software components make and implement decisions themselves (artificial intelligence).

Case Study: Romania and the 4.0 Automotive Industry

Long considered one of the most harmful industries (both in terms of manufacturing and of the use of the resulting products), the automotive industry is now "forced" by the great European powers (viz., Germany) to reinvent itself for polluting less. Reinvention involves, in addition to the adoption of electric or hybrid alternatives to current fuel engines, the use

of industrial digitization. Currently, Romania is one of the European countries with a wide network of car component manufacturers. Although only Dacia (in Mioveni/Colibași) and Ford (in Craiova) assemble cars in Romania, many other companies produce parts over here without which vehicles from many other corners of the planet could not be finalized: Continental (tires, with working units in Timișoara, Sibiu, Carei, Brașov and Iași), Autoliv (safety systems, Brașov, Lugoj, Sfântu Gheorghe, Reșița, Onești and Rovinari), Walor (passive safety components, Sfântu Gheorghe), SubansambleAuto S.A. (gearboxes, Sfântu Gheorghe), Preh (multifunctional switch parts, Ghimbav), Schaeffler Group (bearings, Cristian/Brașov), Star Assembly (gearboxes, Sebeș), Leoni AG (cables, Mioveni, Pitești, Bistrița and Arad) etc.

These are just some of the factories of car parts manufacturers in Romania. Bringing together the effects of all of these manufacturing processes, there is a strong pressure on the environment. Although beneficial to the economy, the boom in the automotive industry can be a threat to nature. Precisely in this context, Romania can profit from the coexistence of "soft" (high speed internet) and "hard" (the presence of the automotive industry in the country) benefits. By the fact that most of these companies are owned by foreign capital, but also by Romania's membership in an EU in full dual transformation – digital and green –, the pressures of digitalization/greening from abroad will have effects in Romania. Willingly or unwillingly, Romania must align its car industry with both trends. Quality internet can help the faster exchange of information to support more efficient decision-making on resource allocation, with an impact on mitigating the adverse effects of this large industry. In addition, the use of smart software solutions in the automotive industry can pave the way for a circular economy in which the reuse of resources to optimize and extend the lifecycle and, consequently, to avoid waste.

Moving on, the digitization of the domestic automotive industry would not be possible without the existence on the local market of several players in the IT and telecommunications sector, able to provide the necessary digital solutions such as cybersecurity, Robotic Process Automation (RPA), artificial intelligence and machine learning (AI and ML), Big Data Analysis. The providers of such solutions are already present on the Romanian market (IBM Romania, Oracle Romania, Ericsson Romania, Endava Romania, Atos IT Solutions, UiPath, Microsoft Romania, Cognizant Technologies, NTT Data etc.), but equally important is the existence of IT&C consultants who to assist companies (from various industries, such as the automotive industry) implement these solutions. In the absence of a sufficiently digitally/IT-educated staff at the clients' inhouse, consultants can be the link to fill the gap created by the lack of digital qualification among the clients' employees. But, in order for Romania to have specialists in digital skills who can support customers in implementing eco-friendly technological solutions, it is also necessary for schools, high schools and universities to fulfil their role of training these staff.

In addition to the "macro" discussion about the Romanian automotive sector, an example from the "micro" level (economic agent) deserves to be discussed. Thus, one of the examples appreciated as successful industrial digitization in the local automotive market is the company SKF Romania, part of the Swedish group SKF, one of the world's largest manufacturers of bearings and, at the same time, one of the leaders in global industrial digitization. In Sweden, SKF is in a permanent race to equip Big Data and Industrial Internet of Things (IIoT) solutions to extend the life of factory equipment. Through IIoT, for example, sensors, production equipment and other industrial equipment are connected

to the company's internet network to analyse and store data about production and factory activity. The values resulting from the data analysis are made available to equipment operators who can establish development directions for each equipment or for each production line (Kuka, 2021). It should be noted, in context, that one of the biggest enemies of productivity, but also of environmental quality, is the unforeseen shutdown of production capacity due to technological failures.

In order to reduce the incidence of such situations, SKF equips its factories with the latest digital solutions, so that factory managers and production managers can have real-time data on the state of the equipment (e.g., the state of the production lines) and, on the basis of these data, make decisions with a direct impact on production (Vesely, 2020). For example: how much longer can the assembly line be allowed to operate until the next service intervention becomes necessary? As a member of the SKF group, the Romanian subsidiary is also exposed to European eco-digital trends. Although it only offers sales and maintenance service in Romania, the digitalization of the subsidiary has consisted in the development of computer applications available on intelligent mobile communication platforms (smartphones and tablets) that optimize the relational marketing between the company and customers, so that intervention times are reduced (Jurnalul de Afaceri, 2019). A faster solution to the problems that arise leads to a more satisfied customer who can resume operations without wasting too much time and without wasting many other resources during these timeouts. In essence, even the smallest detail that increases the reliability and the efficiency of some economic processes, regardless how trivial, is an indirect form of environmental protection, by the reduction of associated waste.

4. The "hard(ware)" side. Where the digital and the green clash: pollution generated by... non-polluting technologies

The second inference advanced by the present study is that there is also a negative impact of digitalisation on the environment, particularly originating in the "hard" side of cyberspace. Digitalisation, automation and the 4.0 industry in general bring their own environmental challenges, by increasing requirements for electric energy, an increasing need for the production of technologically advanced gear, capable of running software that grows ever more sophisticated, complex and demanding (which implicitly means a greater need to exploit Earth's resources through still polluting processes), while the solution to mitigate these negative outcomes is sought in a mix of public institutions and policies.

Yet, in a way, many such unfavourable developments on the digital-environmental axis can be considered tributary to certain misalignments of public policies in this area which, in spite of claiming a certain type of synchronicity and symbiosis, generate inherent disequilibria and instabilities precisely due to the "artificial" nature of coercive regulations, relative to the "organic-ness" of markets. We do not hold the naive perspective of "deregulated markets" (or unregulated, according to the supporters of statist regulations), but rather that of markets regulated on the basis on legitimate relations that enable responsibility and are consolidated in contracts with properly articulated and safeguarded property rights.

The complexity of negative phenomena associated with the expansion of cybernetic and digital technologies on the ecosystem, beyond the primary impact that can be measured – e.g., high consumption of energy and scarce minerals, along with the various

disintegrating/polluting outputs, such as the emissions of noxious substances in the processes of obtaining and utilising energy and critical materials –, leads to the emergence of new analytical fronts. For example, the "internal" political acceleration of digitalisation and greening reverberates at an "external" level, leading to new geopolitical tensions and pressures. We shall outline two such evocative mini-case studies.

Case study #1: The energy balance account of cryptocurrencies

Cryptocurrencies, an exponent of the ongoing digitalisation trend (Smirna, 2021), have seen an immense increase in their popularity starting with the year 2017, being worth 49.318 Euros according to the Bitcoin – Euro exchange rate as of 13 October 2021. They are not a product of state mechanisms, but rather a reaction, in the digital world, to the latter's habitual intrusions, although states are attempting to become relevant in the realm of blockchain as well. The momentum of cryptocurrencies is linked to such attributes as: the safety of transactions guaranteed by the application of blockchain technologies (which register the entire transaction history), its decentralised nature (thereby allowing access from anywhere in the world which bypasses the political risk of assets being blocked), the anonymity of transactions and the possibility of managing transactions directly (without the aid of brokers or other middlemen), according to European Business Review (2021). Analyst L. Sokolin, cited by Cadigan et al. (2017), believes that the growth of the Bitcoin is an inevitable step in the overall trend towards digitalisation. That said, the impact of cryptocurrencies on the environment is itself a cause for concern. Reiff (2021) notes that the Bitcoin as well as other cryptocurrencies require immense amounts of energy for the computations they perform while mining, whereas 65% of all such operations are conducted in China which uses electricity provided mainly by coal power. Moreover, the author warns that, as the price of the Bitcoin continues to grow, the mining process will become that much more inefficient because, although the number of transactions remains constant, the volume of required computation will grow. An analysis by Cho (2021) leads to a similar conclusion, namely that Bitcoin transactions consume up to 121.36 Terawatt-hour, which is comparable to Argentina's total electricity consumption. However, there are also optimistic outlooks on the ecological role of the Bitcoin, with a notable remark from the United Nations (2021), i.e., that, despite the environmental dangers associated with Bitcoin transactions, the transparency and security generated by the blockchain technology can also be used to prevent certain activities from the informal economy that can negatively affect the environment, such as illegal fishing.

Case study #2: Digital pollution and digital waste

The digital "invasion" of the environment can take two forms: pollution by overexertion in certain activity in cyberspace and the waste resulting from the conclusion of the moral/physical lifecycle of equipment and gear. Digital pollution occurs when the activity of users in cyberspace causes negative externalities, meaning there is a "digital carbon footprint" associated with web surfing or posting on social media, hence the corrective concept of "Green IT". Digitalisation is considered an option to diminish "analogical" pollution (e.g., paper waste), but we need to bear in mind the odd turn that digital consumption can take: the growth of the digital carbon footprint (Bridges and Eubank, 2020), associated with irresponsible digital consumption containing spam email, trojans, other viruses etc. (da Silva et al., 2020). Misra et al. (2021) point out that the acceleration of the Industrial Revolution 4.0 will lead to greater digital pollution, exemplified by 5G technologies, which mean greater web navigation speeds, faster data transmission and

greater volumes of multimedia data exchanges: the greater the online "traffic", the more computing power and energy will be required. Nwankpa și Datta (2017) claim that there must be a balance between the exploration and exploitation of digital solutions, otherwise the "new crude oil" as we know it risks being just as dangerous as the classical one, if used excessively. Aside from this, there is pollution generated by electronic and electric waste – the so-called *e-waste* – which covers an array of various products that are discarded once they are used: large household appliances (washing machines and electrical heating devices) make up more than half of the electronic waste collected, followed by IT and communications equipment (laptops, printers), consumption equipment and photovoltaic panels (video cameras, fluorescent lamps) as well as small household appliances (vacuum cleaners, toasters). The problem occurs the moment such equipment is not recovered: in the EU, the leading world champion in the circular economy (especially as regards *policy* targets), less than 40% of electronic waste is recycled.

Conclusions

It is not yet clear what is the net result of the "eco-balance" that follows from the transitioning of a large part of the world and social life to cyberspace. We have, on the one hand, some lessening of the anthropogenic pressure on the environment/climate (e.g., by optimizing some production processes, as enabled by Artificial Intelligence etc.). On the other hand, we have the build-up, by no means negligible, of the pressure on some components of the natural environment (e.g., by the expanding need for energy or rare minerals, which are critical requirements for the new technologies etc.). We categorized the possible ecological relaxations to come on the "software" side of digitization, and tensions as being tributary to the "hardware" side. The discussion is important not only for reporting the spontaneous intersections and interactions between two global megatrends – digitalization and cleaning up the environment –, but also to signal that, beyond the limited predictability of these reciprocal reverberations, some specific issues become manifest when they are tackled as a matter of public policy.

What we attempted to draw attention to in this analysis is that, beyond the good intentions of policy makers when they issue norms that seek to bring about a change for the better in long term habits (even though it is admitted they may be costly for now), we must not omit the unintended consequences that appear when the legislative process exceeds what is deemed lawful/legitimate by the abiding citizen. Forcing the pace of human "progress" via a virulently interventionist/statist approach, even when it employs in addition to regulations financial incentives (paid also from public resources), results in behavioural distortions on the part of economic agents (eviction but also rent-seeking), discoordination of the structure of production (under- and over- investments), economic and social instability in various sectors, leading to the withering away of (individual) responsibility in the name of (social) responsibility.

The mathematician Gottfried Leibniz once said *"natura non facit saltus"* ("nature does not make jumps"), to describe the evolutionary character of natural change. Looking back at the history of human activity through the millennia, it becomes clear that industrial revolutions, the produce of the incremental accumulation of inventions and improvements, lead to betterment of human life which, although appearing gradual from the point of view of subjective experience, seems to be a succession of veritable jumps when one considers

their timing on the grand scale of history. What is keep in mind is that throughout this suite of evolutionary and revolutionary developments (or devolutions) there is a lesson to be drawn, which amounts to a "jump off into the unknown": you can either succeed or commit an error when you impose on people certain means and claim that you know better than them what their goals are; but you invariably fall into error when you "debase" individuals making them the silent means of "all too high" goals.

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